Research Brief for
DOE/IHEA Process Heating Materials Forum

Research Title: Advanced Nanoporous Composite Materials for Industrial Heat Applications

Industry Need: This project is developing new, high performance insulating materials for use in industrial heating applications such as glass melting, steel production, metal casting, and heat treatment. For many years, the production if refractory materials for heat processing was a commodity business, wherein the price is based on price-per-ton of refractory material. More recently, some domestic firms have begun to develop a higher margin specialty business where the purchasing decision is based upon the cost of refractory per ton of product produced. This research is responding to this trend by developing more advanced materials for improved cost effectiveness in the process heat industry.

Existing Research: Composite materials may be made with thermal and mechanical properties tailored to the application. We have been following an approach for creating these materials based on sol-gel technology to create a multi-component porous gel, followed by supercritical solvent extraction and post processing. New nanoporous ceramics based on alumina, chromia, zirconia, silica, and various other mixed oxides are prepared from primary and binary metal alkoxide compounds and other less expensive sol-gel precursors that are being developed. The advantage of these materials will be to provide superior insulation and corrosion resistance in high temperature furnaces and thermal processing equipment in a variety of industrial applications that will substantially increase energy efficiency, product reproducibility, and improve material lifetime. High temperature thermal radiation opacification is achieved through the use of fiber and powder additions to the sol before gelation.

Insulating materials generally benefit from the low bulk densities obtainable with standard aerogel formulations. However, aerogel materials are not limited to such densities and can be prepared with porosities ranging from 25-99.9%. At lower porosities, the mechanical weaknesses found in very high porosity aerogels are absent, though they still possess many of the desirable properties of low density aerogels, These include, an open pore network of mesopores and a tortuous solid network of nanometer-scaled solid particles. This results in a very low level of thermal solid conductivity even for higher density aerogels. Further reduction of thermal conductivity is achieved by the inclusion of fiber and powder opacifants in order to reduce the radiant component of the heat transfer by multiple scattering. These additions also serve to improve the mechanical properties of the material. The combination of specialty oxide aerogels with additional phases to improve the thermal, mechanical, and packaging properties of refractory bricks is the primary goal of this project.

Proposed Activity: The major thrust of this project will be optimizing a specific aerogel or aerogel composite material to the precise thermal, mechanical, and chemical requirements of a given industrial process. This presents no insurmountable obstacles other than the evaluation of many individual compositions and the optimization of the most likely candidates. The metrology of such materials is also well established and can be performed either in-house or at an outside analytical lab. The major goal of this project involves developing aerogel composite materials that retain the advantageous properties of standard aerogels, while increasing their mechanical properties to the levels necessary to meet the needs of the IOF's. Secondary goals are matching a specific aerogel composite composition to the specific needs of individual IOF's

Lead Scientist: Dr. Arlon Hunt
Dr. Michael Ayers
70-108
Lawrence Berkeley National Laboratory
Berkeley, CA 94720
Phone: 510 486 5370
Fax: 510 486 7303
Email: ajhunt@lbl.gov